Notes on soil predatory mites: the genus *Lasioseius* with a newly recorded species and key from China (Acari: Mesostigmata: Blattisociidae)

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Abstract: This paper presents a new record of *Lasioseius* Berlese in China, *Lasioseius japonicas* Ehara, with descriptions of the female. Specimens of *L. japonicus* were collected from the laboratory culture of *Athetis lepigone* Moschler (Lepidoptera: Noctuidae) in Shandong Agricultural University and deposited in the Laboratory of Systematic and Applied Acarology, Shandong Agricultural University (SDAU). *L. japonicus* has shown promise of being a biological control agent of *Bradysia odoriphaga* in laborat ory observations. A key to the females of *Lasioseius* species from China is provided.

Key words: Phytoseioidea; taxonomy; *Lasioseius japonicas*; control

土壤捕食螨——中国毛绥螨属一新纪录种记述及检索表（蜱螨亚纲：中气门目：蠊螨科）

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摘要：记述在二点委夜蛾 *Athetis lepigone* Moschler 人工培养基中发现的毛绥螨属 *Lasioseius* Berlese 1 中国新纪录种——日本毛绥螨 *Lasioseius japonicus*。对雌成螨进行了重描述，绘制了特征图，编制了中国毛绥螨属雌螨分种检索表。此外，通过实验室观察发现该种具有防治韭蛆 *Bradysia odoriphaga* 的潜力。标本保存于山东农业大学系统与应用蜱螨学实验室。

关键词：植绥螨总科；分类；日本毛绥螨；防治

Introduction

Soil predatory mites are natural enemies of some pests including certain insects, acarine and edaphic pests (Diptera, Thysanoptera, Astigmata) (Navarro-Campos *et al*. 2012; Wu *et al*. 2014; Moreira & Moraes 2015; Saito & Brownbridge 2016). It has been documented that mites of the Blattisociidae can feed on such pests as *Tyrophagus putrecentiae* Schrank (Sarcoptiformes: Acaridae), *Steneotarsonemus spinki* Smiley (Trombidiformes: Tarsonemidae), *Polyphagotarsonemus latus* Banks (Trombidiformes: Tarsonemidae), *Tetranychus kanzawai* Kishida (Trombidiformes: Tetranychidae) and *Bemisia tabaci* (Gennadius) (Hemiptera:

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Aleyrodidae) (Chow & Liu 1984; Tseng 1984; Rodríguez-Cruz *et al*. 2017). This suggests that Blattisociid mites may be potential biocontrol agents of some pests.

As soil predatory mites, *Lasioseius* Berlese is usually classified as an independent genus in the family Blattisociidae, order Mesostigmata, subclass Acari in class Arachnida (Karg 1980; Christian & Karg 2006). This genus contains 200 known species worldwide (Moraes *et al*. 2016) and 35 of these have been recorded in China (Christian & Karg 2006; Zhang & Fan 2010). We recently collected *Lasioseius japonicus* Ehara from a laboratory culture of *Athetis lepigone* (Lepidoptera: Noctuidae) in Shandong Agricultural University. This species was originally described on the basis of specimens collected in bulb mites (*Rhizoglyphus echinopus* Fumouze & Robin) culture in Niigata, Japan (Ehara, 1965); since then, this species has not been reported elsewhere in the world. Thus this paper represents a new record of this species for China and increases the Chinese fauna of *Lasioseius* to 36 species. Also we provide a revised identification key to species of *Lasioseius* from China that helps define natural species groups. In addition, a culture of *L. japonicus* on *T. putrecentiae* was successfully established in the Laboratory of Systematic and Applied Acarology, Shandong Agricultural University, Shandong, China.

Material and methods

All adults of *L. japonicus* were picked from a laboratory culture, placed in 75% alcohol and then cleaned in distilled water before mounting in Hoyer's medium. Morphological observations were made under a differential interference contrast microscope (Nikon Eclipse Ni-U). Line drawings were made using a drawing tube. The average measurement is followed (in parentheses) by the minimum and the maximum measurements in micrometres (μm). Idiosomal setal nomenclature follows that of Lindquist & Evans (1965) as modified by Lindquist (1994). Leg setal notation and chaetotaxy are based on Evans (1963). The notation for idiosomal pore-like structures (gland pores and poroids) follows mostly that of Athias-Henriot (1975), adapted by Kazemi *et al*. (2014). Voucher specimens of these mites were deposited in the Laboratory of Systematic and Applied Acarology, College of Plant Protection, Shandong Agricultural University (SDAU).

Taxonomy

Genus *Lasioseius* Berlese, 1916

Diagnosis. The genus diagnosis follows Moraes *et al.*, 2016: 41–43.

***Lasioseius japonicus* Ehara, 1965** (Figs. 1–11), new record to China

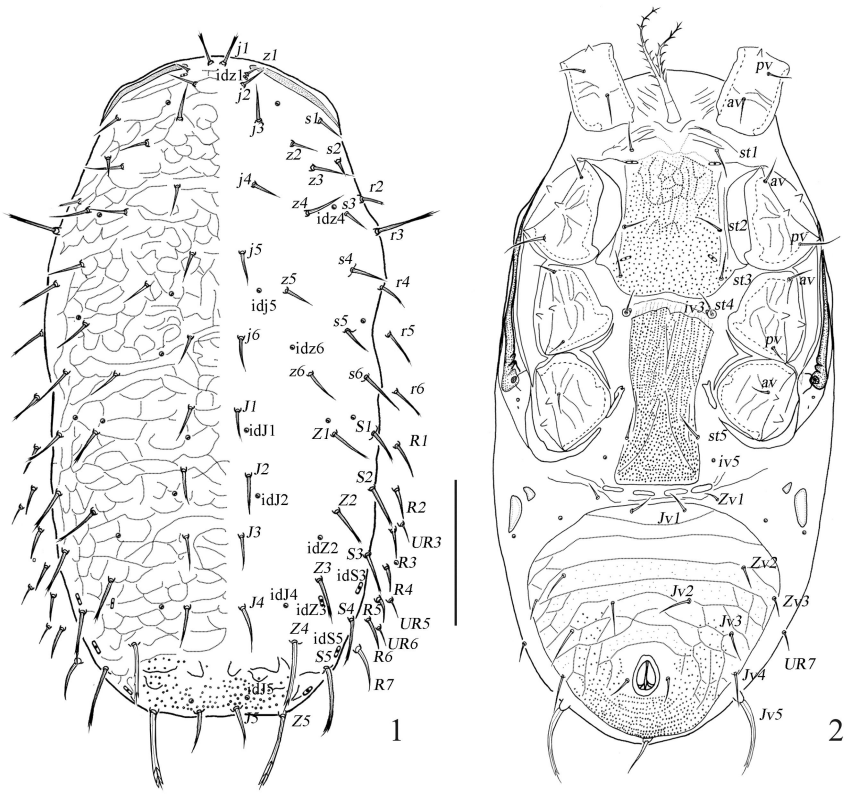
Lasioseius japonicus Ehara, 1965: 25.

Specimens examined. 3♀, coll. by Dr. Fangqiang ZHENG, from culture with *A. lepigone* in the Laboratory of Insect Ecology and Pest Management, Shandong Agricultural University, Shandong, China, 14-III-2016. All specimens were deposited in the Laboratory of Systematic and Applied Acarology, Shandong Agricultural University, Shandong, China.

Female (n = 3) (Figs. 1–11)

Dorsal idiosoma (Fig. 1). Dorsal shield strongly reticulate, 499 (494–509) long and 256

(249–265) wide at level of *r3*. Shield with 36 pairs of setae, all arising from small tubercles, and 21 pairs of these (*j1–j6*, *z1–z6*, *s1–s6*, *r2–r4*) on the podonotal region, the opisthonotal region having 15 pairs of setae (*J1–J5*, *Z1–Z5*, *S1–S5*). Setae *j2–j6*, *J1–J5* tricarinate; setae *j1*, *r2–r6*, *Z1–Z5* and *S1–S5* flanged, *Z4* with two barbs only on one side (Figure 3); setae of *J* series shorter than distances between bases, so not reaching base of following setae; without unpaired setae. Shield with five pairs of discernible poroids (oval-shaped symbols) and 12 pairs of gland pores (circular symbols). Unsclerotised cuticle laterad of dorsal shield with nine pairs of marginal setae of mostly similar lengths and shape (*r5–r6*, *R1–R7*), three pairs of submarginal setae (*UR3*, *UR5*, *UR6*), with one pair of pore-like structures between *R3* and *R4*. Measurements of dorsal setae are shown in Table 1.



Figures 1, 2. *L. japonicus* Ehara 1965, ♀. 1. Dorsal idiosoma; 2. Ventral idiosoma. Scale bar = 100 μm.

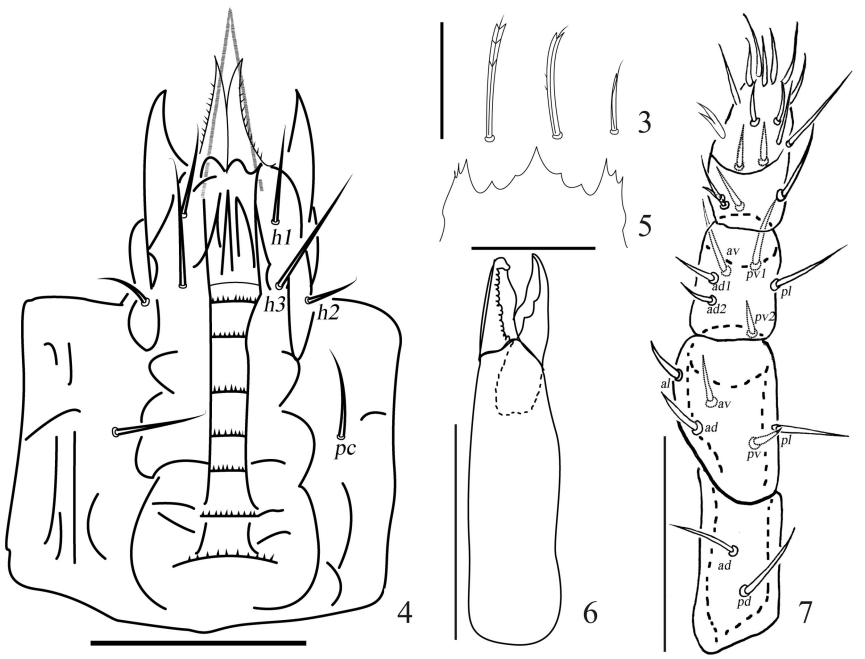
Ventral idiosoma (Fig. 2). Tritosternum with tubular base and free pilose laciniae. Presternal area weakly sclerotised, with several lines. Sternal shield punctate, anteromedian region of shield reticulate and with few minute punctures, 115 (113–118) long, minimum width between coxae II 87 (85–88), maximum width between coxae II–III 135 (133–140), anterior margin of shield not obvious, posterior margin slightly concave. Setae *st1* located in presternal area, sternal shield with two pairs of setae (*st2*, *st3*), and two pairs of slit-like lyrifissures (*iv1*, *iv2*), *iv1* located in anterior margin of shield. Metasternal platelets rounded, bearing *st4* and lyrifissures *iv3*. Epigynal shield beaker-like, punctate, 136 (130–143) long,

including anterior hyaline flap, width between the level of *st5* 60 (53–68), bearing genital seta (*st5*), paragenital lyrifissures (*iv5*) on unsclerotised cuticle posterolaterad of *st5*. Four transversely aligned elongate platelets between epigynal and ventrianal shields. Two pairs of metapodal platelets, anterior pair triangular to nearly circular, posterior pair conspicuously larger and elongate; a pair of poroids lying posterior to each posterior metapodal platelet. Ventrianal shield large, wider 195 (184–203) than long 164 (157–172), with conspicuous reticulation, punctate posteriorly, especially posteriad of *Jv2*, with six pairs of opisthogastric setae in addition to circumanal setae; anal opening not enlarged, 25–33 long. Three pairs of opisthogastric setae (*Jv5*, *Zv1*, *Zv4*) on unsclerotised cuticle surrounding ventrianal shield, setae *Jv5* considerably larger, on small projections, flanged. Endopodal plates between coxae III-IV V-shaped, free. Exopodal plates large, extending from posterior level of coxae II to level of coxae IV. Peritreme extending anteriorly to base of seta *z1*. Peritrematic plate fused with dorsal shield at level of *s1* and fused to exopodal shields at level of coxa IV. Measurements of ventral setae in Table 1.

Table 1. Measurements (μm) of characters of *L. japonicus* Ehara 1965 (*n* = 3)

Structures	Female	Structures	Female
j1	25, 25, 25	*Z2*	35, 33, 33
j2	25, 25, 25	*Z3*	38, 35, 38
j3	28, 28, 28	*Z4*	50, 50, 50
j4	25, 25, 25	*Z5*	65, 60, 60
j5	25, 25, 28	*S1*	35, 35, 35
j6	28, 28, 25	*S2*	40, 38, 35
z1	13, 13, 13	*S3*	40, 40, 38
z2	23, 25, 23	*S4*	48, 48, 43
z3	35, 33, 33	*S5*	53, 50, 48
z4	30, 28, 28	*R1*	30, 28, 28
z5	23, 25, 25	*R2*	28, 25, 25
z6	28, 28, 28	*R3*	25, 25, 25
s1	28, 25, 25	*R4*	25, 25, 23
s2	18, 15, 15	*R5*	28, 28, 28
s3	30, 33, 33	*R6*	25, 25, 28
s4	30, 30, 30	*St1*	25, 25, 25
s5	35, 33, 30	*St2*	23, 23, 23
s6	38, 33, 38	*St3*	23, 25, 23
r2	23, 20, 20	*St4*	23, 23, 23
r3	48, 45, 45	*St5*	20, 23, 20
r4	35, 33, 33	*Jv1*	20, 20, 20
r5	35, 35, 33	*Jv2*	25, 23, 23
r6	30, 28, 30	*Jv3*	28, 25, 25
J1	25, 25, 28	*Jv4*	23, 23, 25
J2	33, 28, 25	*Jv5*	48, 45, 43
J3	33, 30, 30	*Zv1*	15, 15, 15
J4	35, 33, 33	*Zv2*	23, 23, 23
J5	33, 33, 33	*Zv3*	13, 15, 20
Z1	30, 33, 30	*Zv5*	18, 18, 18

Gnathosoma (Figs. 4–7). Fixed digit of chelicerae 46 (43–48) long, with 16 small teeth; movable digit 46 (45–48) long, with three teeth (Figure 6). Epistome usually with three main anterior extensions which all have few denticles on lateral edges, median projection slightly longer than laterals (Figure 5). Deutosternum with distinct lateral lines, flanked by seven transverse denticulate lines, each with 7–10 denticles. Setae *h1* 25 (23–27) > *h3* 25 (16–25) > *h2* 18 (11–25), capitular (*pc*) setae smooth 25 (23–27). Corniculi length 33 (33–34), horn-shaped, subparallel to each other. Palpus (Figure 7) 164 (160–170) long, number of setae on palp segments from trochanter to tarsus: 2–5–6–14–15, apotele two-tined.



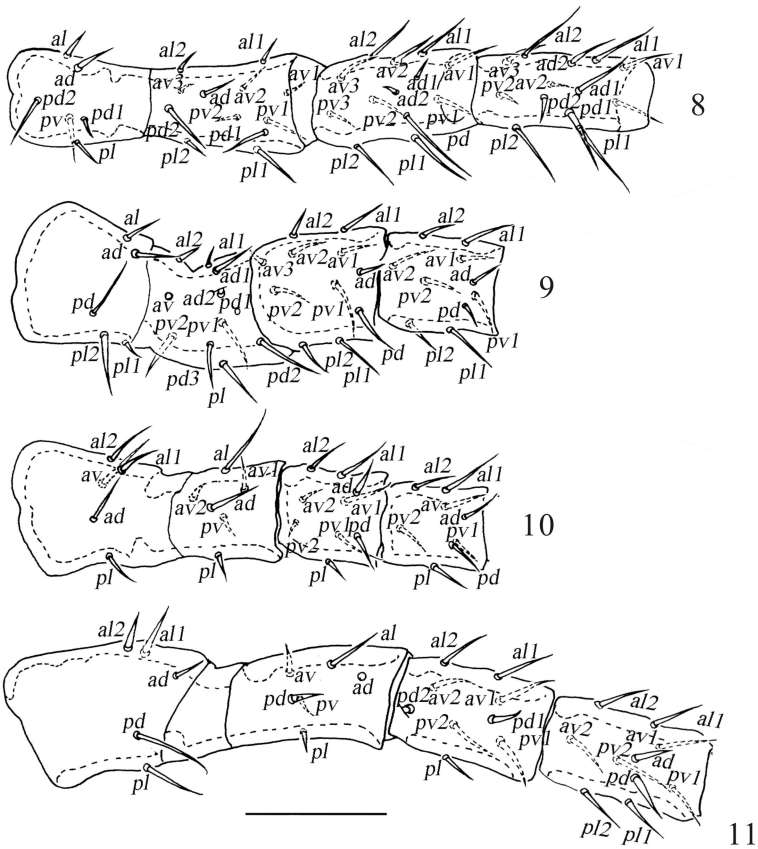
Figures 3–7. *L. japonicus* Ehara 1965, ♀. 3. Dorsal setae; 4. Gnathosoma; 5. Epistome; 6. Chelicera; 7. Palp. Scale bars = 50 μm (Figs. 3, 4, 6, 7); 20 μm (Fig. 5).

Legs (Figs. 8–11). Legs I–IV with paired claws, and pulvillus with three rounded lobes, inserted on well-developed pretarsi. Length of legs I–IV (excluding pre-tarsus) 470 (463–479), 365 (331–382), 372 (361–377), 487 (484–494), respectively. Setae aciculate. Leg chaetotaxy as shown in Table 2.

Table 2. Chaetotaxy on legs of *L. japonicas* Ehara, 1965.

Leg	Trochanter	Femur	Genu	Tibia
I	1, 1/0, 2/1, 1	2, 1/3, 2/2, 2	2, 2/3, 1/3, 2	2, 2/3, 2/2, 2
II	1, 1/0, 1/0, 2	2, 2/1, 3/2, 1	2, 1/3, 1/2, 2	2, 1/2, 1/2, 2
III	2, 1/1, 0/0, 1	1, 1/2, 0/1, 1	2, 1/2, 1/2, 1	2, 1/1, 1/2, 1
IV	2, 1/0, 1/0, 1	1, 1/1, 1/1, 1	2, 0/2, 2/2, 1	2, 1/2, 1/2, 2

* Chaetotaxy of legs on each section represented as *al*, *ad/av*, *pd/pv*, *pl*



Figures 8–11. *L. japonicus* Ehara 1965, ♀. Right legs, dorsal aspect. 8. Leg I; 9. Leg II; 10. Leg III; 11. Leg IV. Scale bar = 50 μm.

Discussion

General discussions of a newly recorded species. Based on the key to the genus *Lasioseius* (Christian & Karg 2006), and the comparison with the original description and illustrations of the female, we identified the specimens as *L. japonicus.* The main features of the specimens (female) are identical to the original description (in Japan) and are as follows: the shape of setae on dorsal shield all flanged but now most unobvious in the medium segment of dorsal shield; four elongate platelets imbedded under surface between genital and ventrianal shields and revealing the surface is folded-like; ventrianal shield large, wider than long, reticulate, punctate, with six pairs of pre-anal setae; three pairs of metapodal platelets, the largest pair triangular to nearly circular; fixed digit with 16 teeth, the movable digit with three teeth.

Comments on their potential as biocontrol agents against *Bradysia odoriphaga*. We have raised these mites in the laboratory feeding on *Tyrophagus putrescentiae* (Acari: Acaridae). Based on our laboratory observations, the most accidental discovery is that the mites can

consume eggs and larvae of *B*. *odoriphaga.* Therefore we carried out studies of predation of this species on *B*. *odoriphaga* egg and larvae. The preference of this predatory mite to different stages of *B*. *odoriphaga* was studied. The results show that *L*. *japonicas* prefers to prey on larvae and then eggs but not pupae; so this species is a promising biological control agent of *B*. *odoriphaga*.

Key to species of *Lasioseius* from China based on the female

1. Only one metapodal plate on each side of the body behind coxae IV. Dorsal setae almost acicular or pectinate, rarely trispinate ·····2
-. Metapodal plates divided into two little plates (the two plates are sometimes fused), dorsal setae acicular or trispinate or pectinate ·····9
2. Ventrianal shield with 3 pairs of setae ·····*L. allii*
-. Ventrianal shield with 4–7 pairs of setae ·····3
3. Ventrianal shield longer than wide, sternal shield medially with a layered-like structure, most dorsal setae tricarinate, caudal dorsal setae pectinate ·····*L. sinensis*
-. Ventrianal shield wider than long ·····4
4. Sternal shield smooth; tectum with 3 short branches, equal in length, distally serrate ·····*L. qianensis*
- Sternal shield punctate ·····5
5. Ventrianal shield with 5 pairs of setae; tectum with 3 short broad branches, the middle branch longer than the lateral branches, the branches distally serrate, dorsal setae relatively long, the length of *J5* = distance *J5–Z4* ·····*L. trifurcipilus*
-. Ventrianal shield with 6 or 7 pairs of setae ·····6
6. Ventrianal shield with 6 pairs of setae; tectum with 3 branches, branches short and broad, apically serrate; number of dorsal setae not reduced, most of dorsal setae acicular, caudal dorsal setae pectinate, *j1* = 2/3 the length of *J3* ·····*L. punctatus*
-. Ventrianal shield with 7 pairs of setae; tectum serrate, number of dorsal setae reduced ·····7
7. Dorsum without *J2* and *J5*, caudal setae of dorsum and venter distally furcate, metapodal plates like small rods, sternal shield and ventral shield reticulate·····*L. schizopilus*
-. Dorsum without *J2* and *J3*…·····8
8. Setae of the ventral shield nearly equal in length, only postanal seta short: = 1/2 the length of the adanal setae; dorsal setae *Z3* = 3.5 times the length of *J4*·····*L. parberlesei*
-. Seta *V1* of the ventrianal shield remarkably short: = 1/2 the length of *V2*, postanal seta long: = 2 times the length of paranal setae, sternal shield and ventrianal shield reticulate; dorsal setae *J4* very short: = 1/2 the length of *J1* and 1/3 the length of *j6*, tectum with 3 short broad branches distally serrate·····*L. paucispathus*
9. Anus remarkably large, length of anus = 1/4 to 1/3 of the length of the ventrianal shield; ventrianal shield bearing 5 pairs of setae; a number of dorsal setae trispinate, most dorsal setae long, *J1* reaches *J2*, *J2* reaches *J3*, *J3* reaches *J4*; sternal shield with a longitudinally directed structure ·····*L. analis*
-. Anus not remarkably large; ventrianal shield with 5–7 pairs of setae, dorsal setae trispinate or acicular····· 10
10. A number of dorsal setae trispinate ·····11
-. Most dorsal setae acicular, some caudal setae pectinate ·····16
11. Ventrianal shield with 7 pairs of setae ·····12
-. Ventrianal shield with 5 pairs of setae; leg I shorter than the idiosoma ·····13
12. Number of dorsal setae reduced, with 22 pairs; peritreme extending above the level of *j1*; sternal shield with anterior distinct ·····*L. chaudhrii*
-. Number of dorsal setae not reduced, with 36 pairs; peritreme not extending to *j1*; sternal shield with anterior indistinct ·····*L. japonicus*

13. Sternal shield with posterior margin deeply excavated to level of *st2*, tectum with 3–4 groups of points ····· ····· *L. ometes*
-. Posterior margin of sternal shield excavated slightly ····· 14
14. Setae *st1* located separately on presternal area, median point of tectum as long as lateral branches ·····15
-. Setae *st1* located on the sternal shield; median point of tectum twice as long as lateral branches ····· ····· *L. liuchungfui*
15. A very weak linear plate between genital shield and ventrianal shield ····· *L. huangheensis*
-. Four elongate platelets imbedded under surface between genital and ventrianal shields ····· *L. sugawarai*
16. All of the setae on the dorsum smooth and present acicular or bolder, not tricarinate ·····17
-. A number of setae on the dorsum pectinate ····· 19
17. No protruding shoulder setae *r3*, tectum with lateral serrated branches ····· *L. multisetus*
-. Shoulder setae *r3* clearly protruding from idiosoma ····· 18
18. Ventrianal shield with 5 pairs of setae; sternal setae *st1* on the sternal shield, and presternal area without transverse line; *r3* shorter than other dorsal setae ····· *L. liaohaorongae*
-. Ventrianal shield with 7 pairs of setae; sternal setae *st1* on the margin of sternal shield, and presternal area with transverse line; dorsal setae *j1* remarkably long, about 2.5 times of the length of *j6*, *r3* longer than *j2*····· ····· *L. spatulus*
19. Most dorsal setae pectinate, dorsal setae *Z5* = 1.5–3 times the length of *j5* ····· 20
-. Only *S*-setae respectively, *Z*-setae of the posterior half of dorsum pectinate ····· 26
20. Number of dorsal setae reduced, posterior half of dorsum without *J1* and *J3* ·····21
-. Dorsal setae *J1–J5* developed on posterior half of dorsum ····· 22
21. Ventrianal shield remarkably wider than long, width: length = 5 : 4 to 3 : 2, dorsal setae *Z4* = 69–73, *Z5* = 75, leg I = 400–420, leg IV = 475–530 ····· *L. youcefi*
-. Ventrianal shield only slightly wider than long, width: length = 4 : 3.5, *Z4* = 54, *Z5* = 63, leg I = 427, leg IV = 436 ····· *L. lindquisti*
22. Ventrianal shield very broad, bearing 7 pairs of setae ·····23
-. Ventrianal shield bearing 5–6 pairs of setae ····· 25
23. Dorsal setae stronger, longer, and with tiny spines, *j4* = the distance between *j4* and *j5* ····· *L. daanensis*
-. Dorsal setae thinner, shorter and not reaching to the latter setae of the series ·····24
24. Movable digit of the chelicerae with 16–20 teeth, tectum with 3 long broad branches ····· *L. confusus*
-. Movable digit of the chelicerae with 14 teeth, tectum with 3 short broad branches ····· *L. paraconfusus*
25. Dorsal setae shorter and wider, *J1* to *J4* not reaching the next setae of the series, *Z4* not reaching *Z5*, most dorsal setae leaf-like and with midrib; tectum with 3 branches ····· *L. jilinensis*
-. Dorsal setae longer and thinner, *J1* to *J4* reaching the next setae of the series, *Z4* reaching *Z5*···· *L. scapulatus*
26. Ventrianal shield bearing 7 pairs of setae ·····27
-. Ventrianal shield bearing 5 pairs of setae ····· 28
27. Number of dorsal setae reduced, posterior half of dorsum without dorsal setae *J2* and *J3*, ventrianal shield slightly wider than long ····· *L. wangi*
-. Number of dorsal setae not reduced; ventrianal shield extremely broad, length: width = 4 : 7 ····· ····· *L. multispathus*
28. Ventrianal shield distinctly longer than wide ·····29
-. Ventrianal shield as long as wide or wider than long ····· 34
29. Dorsal shield small and narrow ····· *L. plateculus*
-. Dorsal shield broader and almost covering the idiosoma ····· 30
30. Most dorsal setae acicular and thin, however caudal setae *Z5* weakly pectinate, humeral setae tricarinate····· ····· *L. porulosus*

-. Caudal setae *Z5* very stout, club-shaped and serrate, with branches ····· 31
31. Dorsal shield bearing 31 pairs of setae ····· 32
-. Dorsal shield bearing 32 pairs of setae, all dorsal shield setae arising from tubercles, *S5* leaf-shaped ····· *L. fenchihuensis*
32. All dorsal shield setae arising from tubercles; sternal shield slightly convex at the anterior margin, concave posterior ····· *L. taiwanicus*
-. All dorsal shield setae not arising from tubercles ····· 33
33. Only caudal setae*Z5* extremely strong and serrate = 4 times the length of *j5*, S5 seta-like ····· *L. scilliticus*
-. *Z5* and *Z4* long, horn-like and serrate; sternal shield slightly concave at the middle of anterior margin, concave posterior ····· *L. chenpengi*
34. Sternal setae *st1* located on margin of sternal shield ····· *L. medius*
-. Sternal setae *st1* located separately on presternal area ····· 35
35. Dorsal shield bearing 34 pairs of setae; presternal area with transverse line ····· *L. praevius*
-. Dorsal shield bearing 35 pairs of setae; presternal area reticulate ····· *L. qinghaiensis*

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